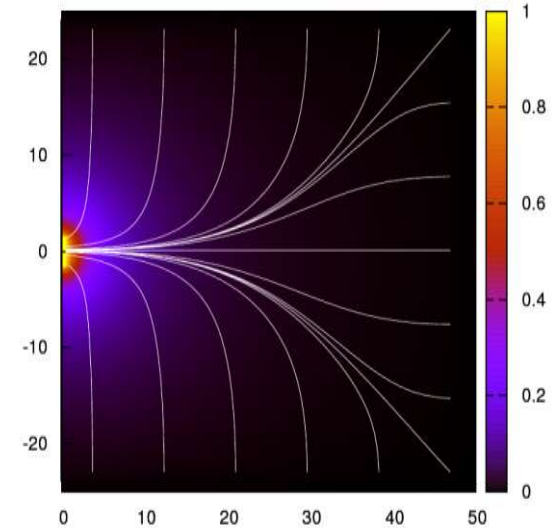
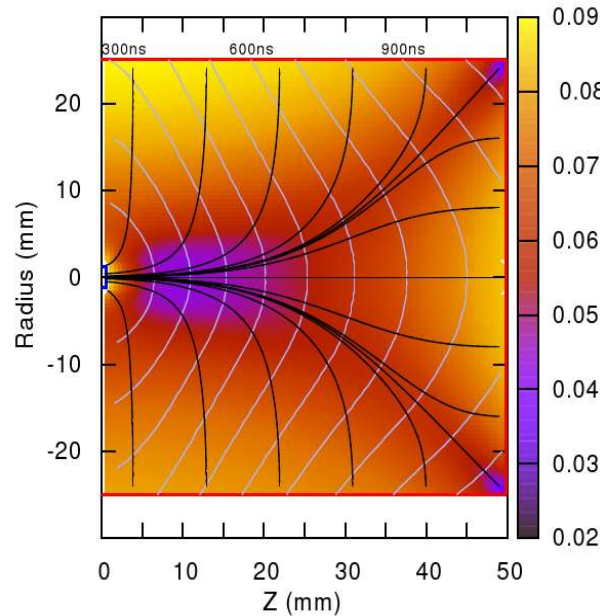
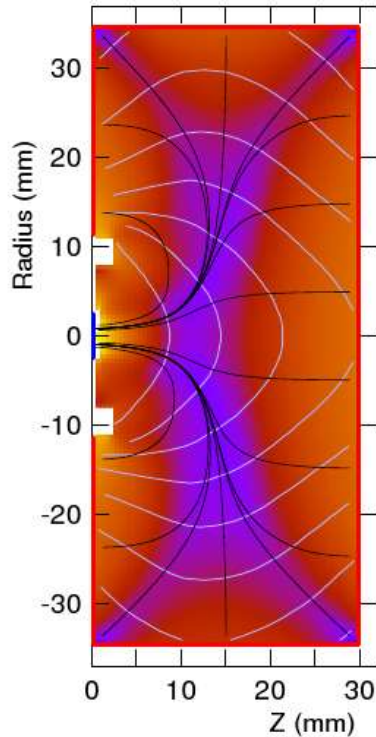


MAJORANA siggen



David Radford

ORNL Physics Division

Final Symposium of the Sino-German GDT Cooperation

Schloss Ringberg

October 2015

Outline

- Overview of **fieldgen** and **siggen**
- New capabilities
 - Capacitance
 - Charge cloud sizes
- Mobilities
- Li transition layer

MJD_fieldgen and MJD_siggen

For CANBERRA (BEGe) and ORTEC PC detectors

- Require cylindrical symmetry in detector geometry
- Both programs use a common 2D grid (r, z) for field and weighting potentials

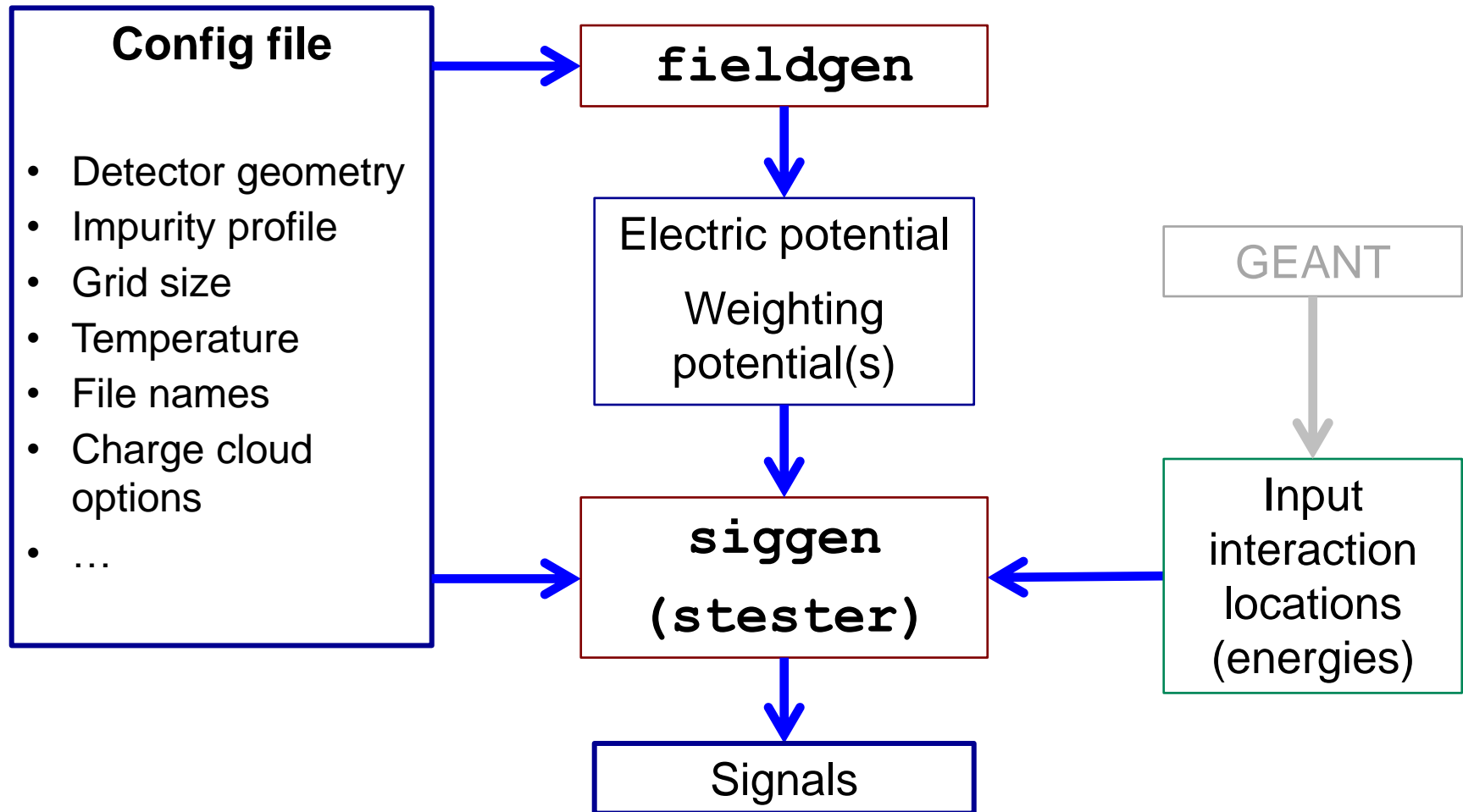
Recent major updates

- One common configuration / geometry file for fieldgen, siggen
- Include effects of charge cloud size, diffusion, and repulsion on the signal shapes
- Code reorganization for easier multi-threading

Code is open source, freely available:

svn://radware.phy.ornl.gov/MJ/mjd_siggen

MJD_fieldgen and MJD_siggen

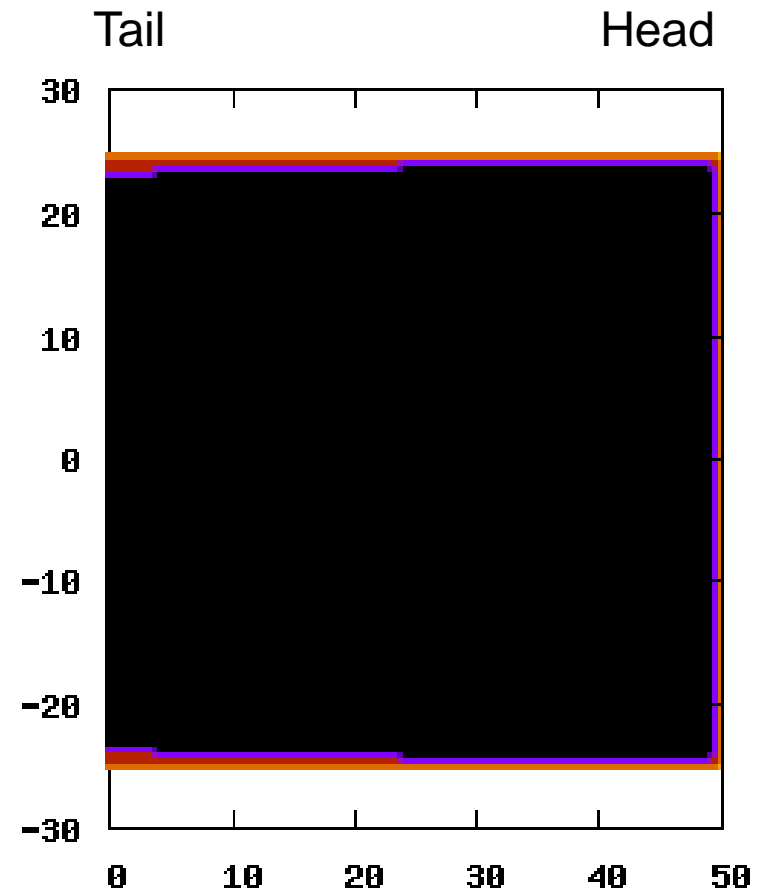
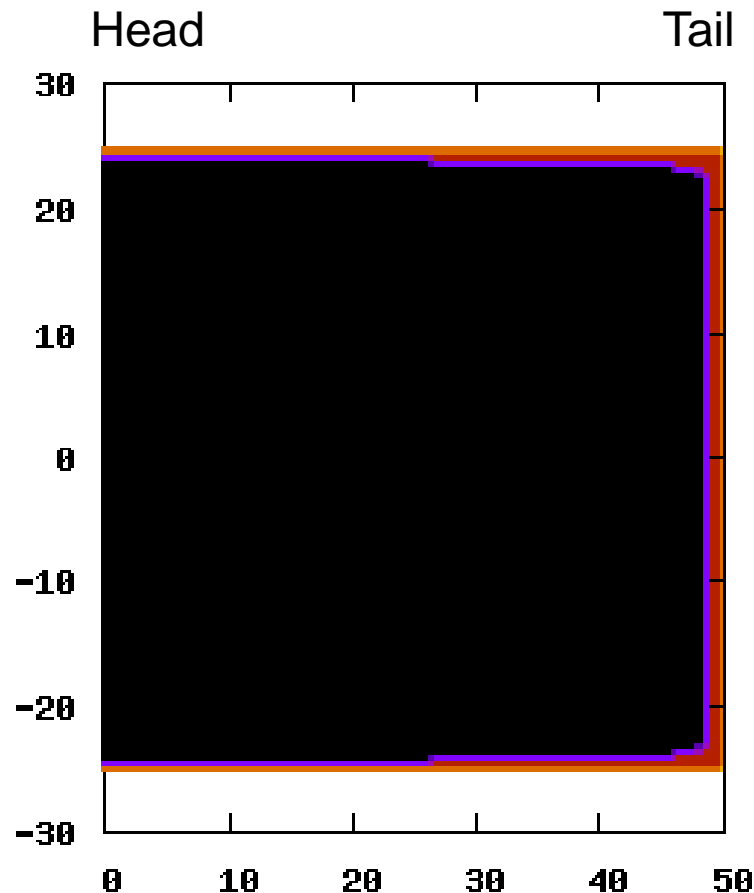


Calculation of electric and weighting potentials

- Stand-alone program
- 2D relaxation, using cylindrical symmetry
 - Simplest boundary condition for passivated surface; parallel field
 - Does not try to include material outside the crystal
- Automatic adaptive grid (coarse -> finer -> finest) to speed up calculation
 - Typically use 0.1 mm grid for MJD PPCs
 - Attempts to deal with partially filled voxels
- Properly handles undepleted volumes
 - Iteratively finds undepleted voxels and sets their space charge to zero
- Calculates capacitance of readout contacts

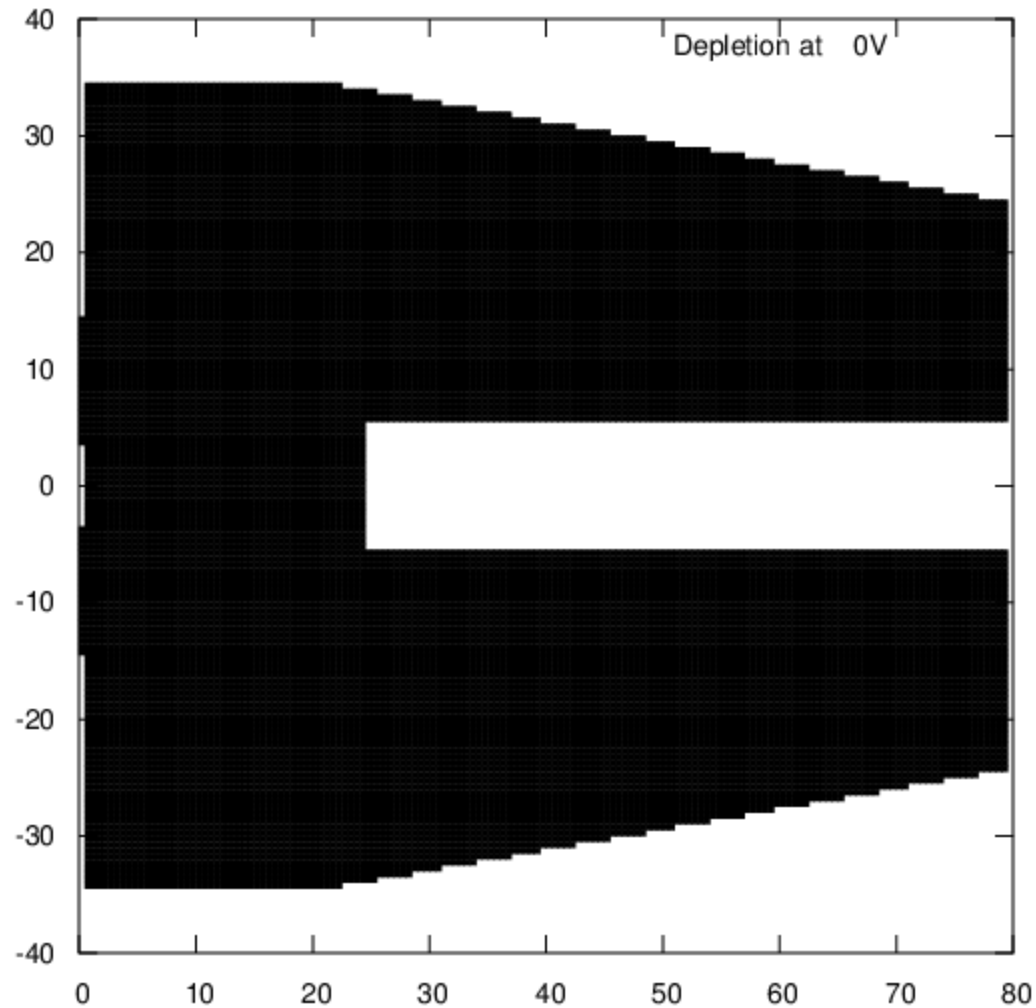
Depletion

- Should always use measured/calculated depletion voltages to validate or adjust the impurity concentration in the config file
- Good and bad PPCs; 100V per step



Depletion

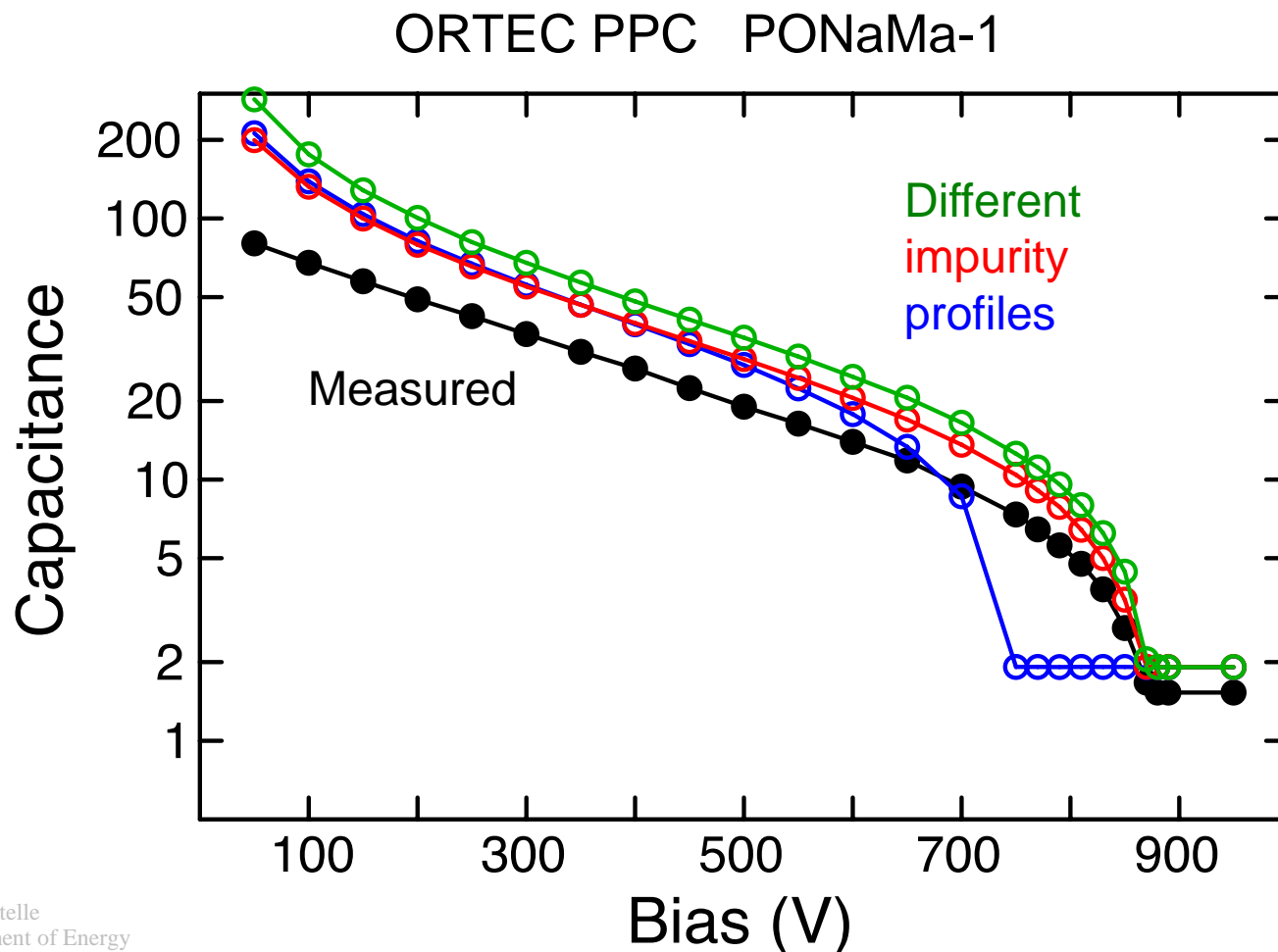
- Segmented inverted-coaxial point-contact detector



Capacitance Curves

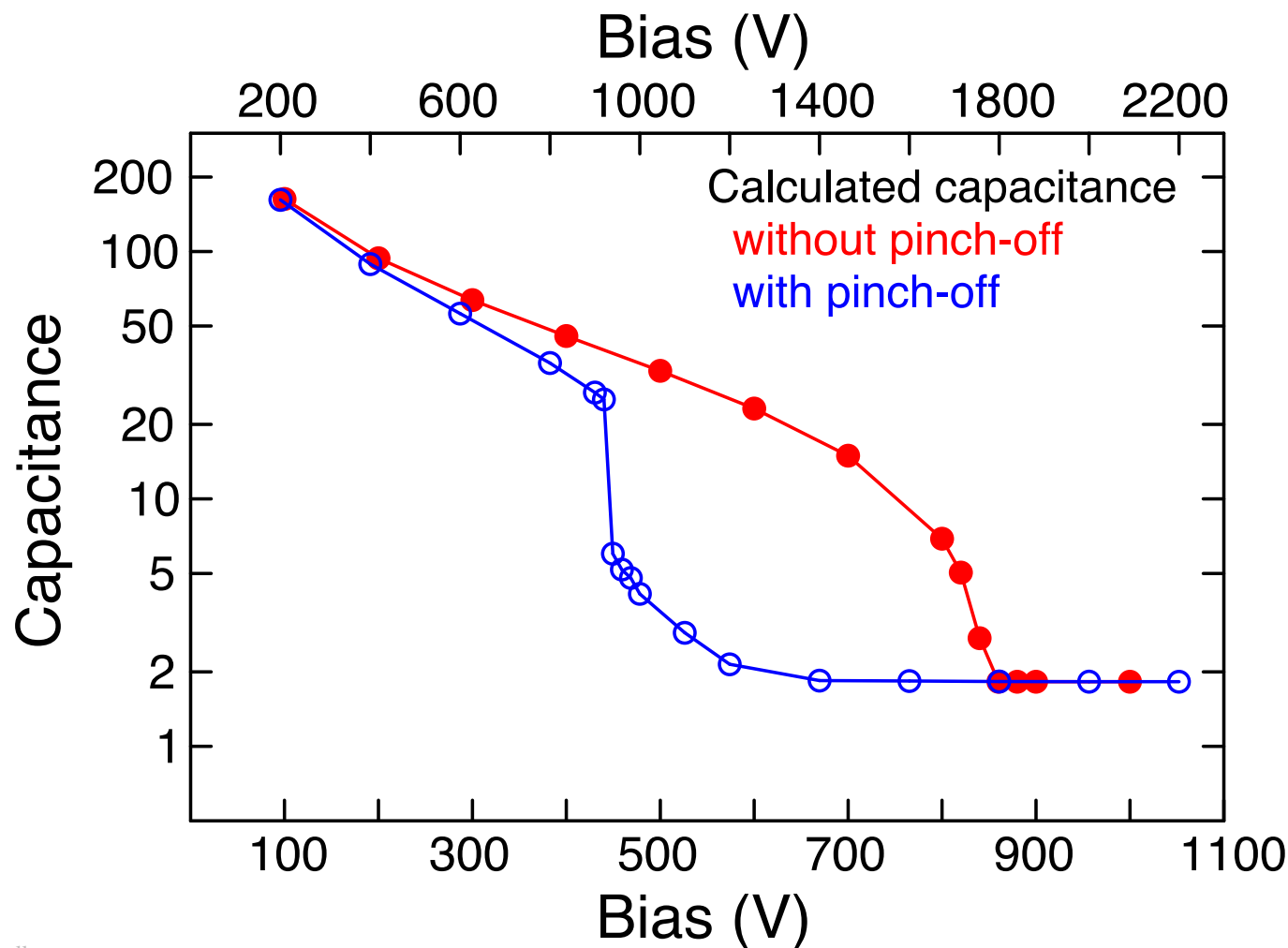
MJD_fieldgen calculation of capacitance vs. voltage

- Calculation (static) always higher than measurement (dynamic)



Capacitance Curves

MJD_fieldgen calculation of capacitance vs. voltage



MJD_siggen

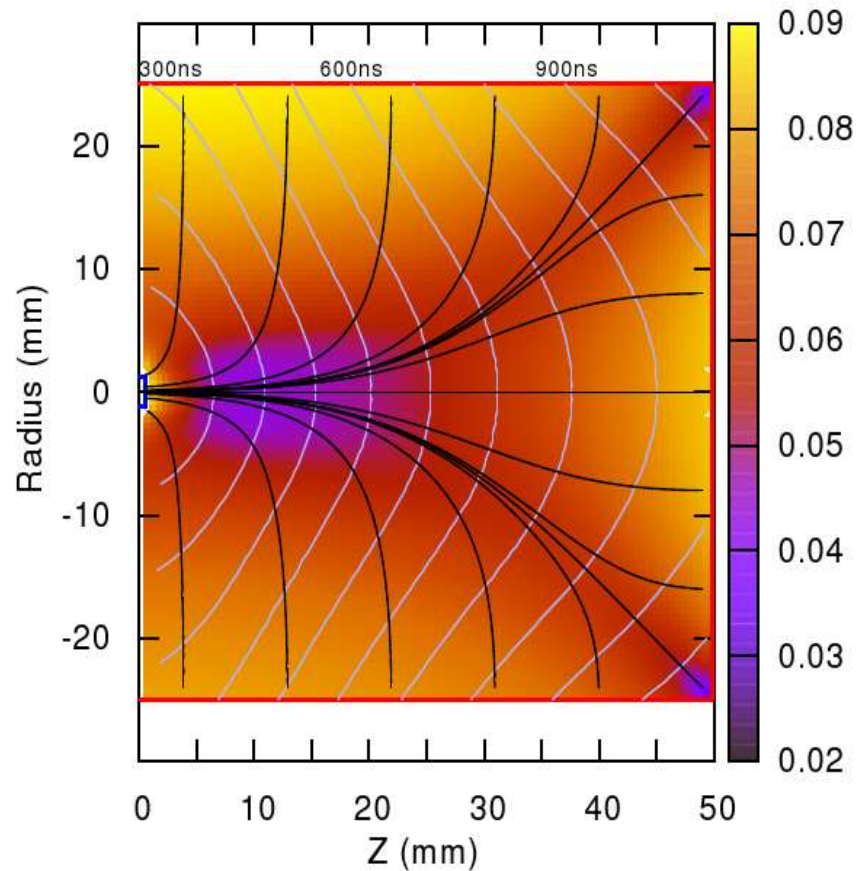
Calculation of signals

- Mobilities
- Temperature dependence
- Crystal orientation
- Charge cloud size, diffusion, repulsion

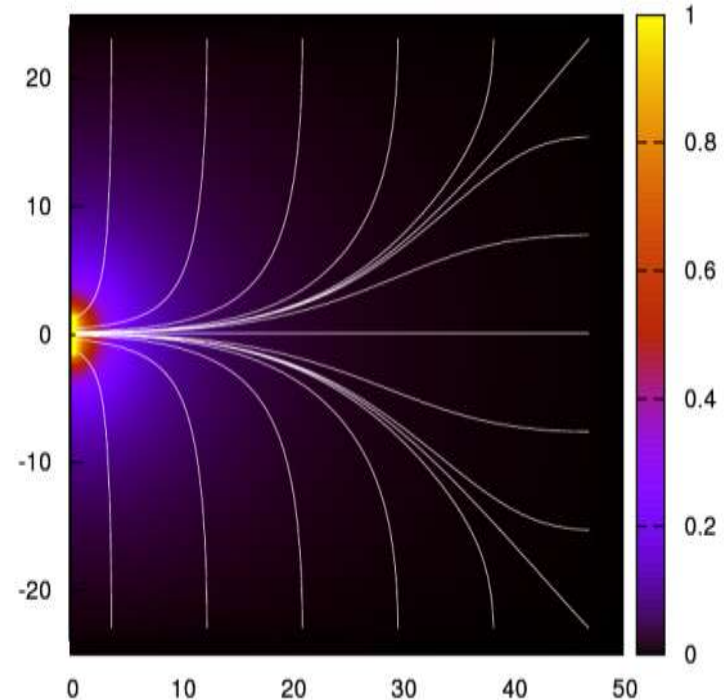
Intended for use as a library

- Easy to calculate sums of MSE signals from GEANT, for example
- Example codes and simple interactive test program provided

Fields and Mobilities for a generic PPC



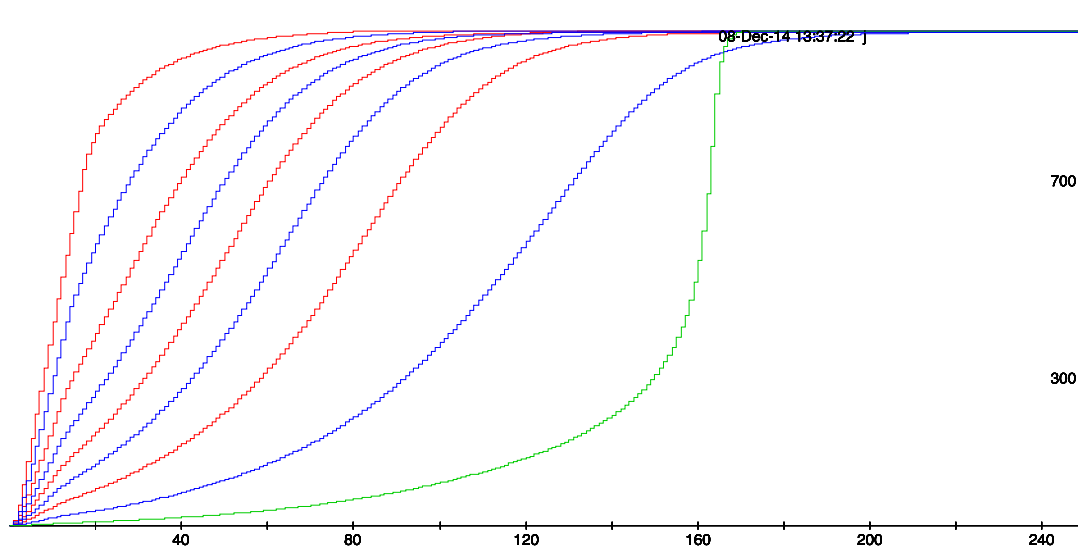
Drift velocity,
paths, times



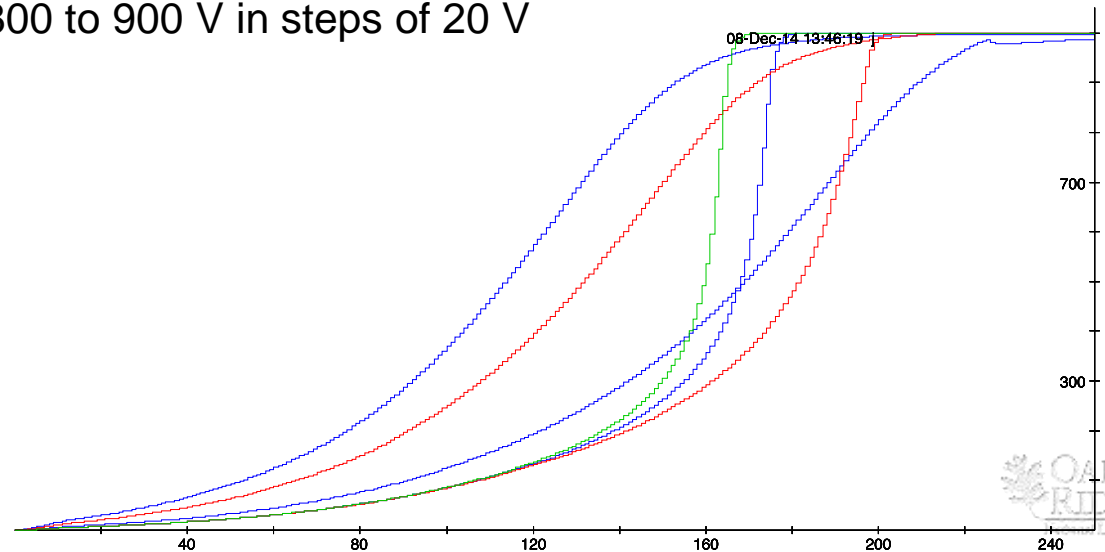
Weighting potential

Signals Calculated Near and Above Depletion

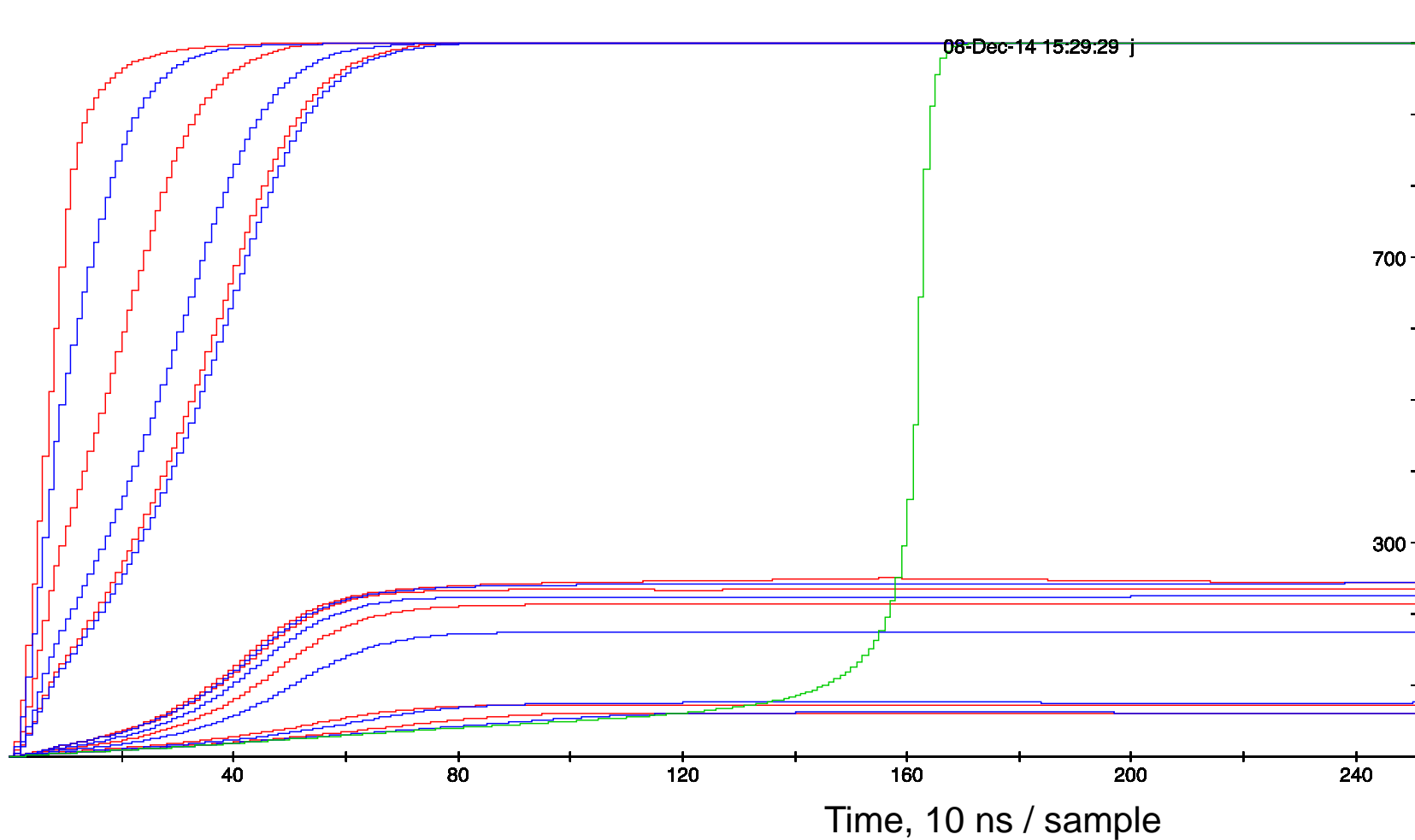
100 to 900 V in steps of 100 V



800 to 900 V in steps of 20 V

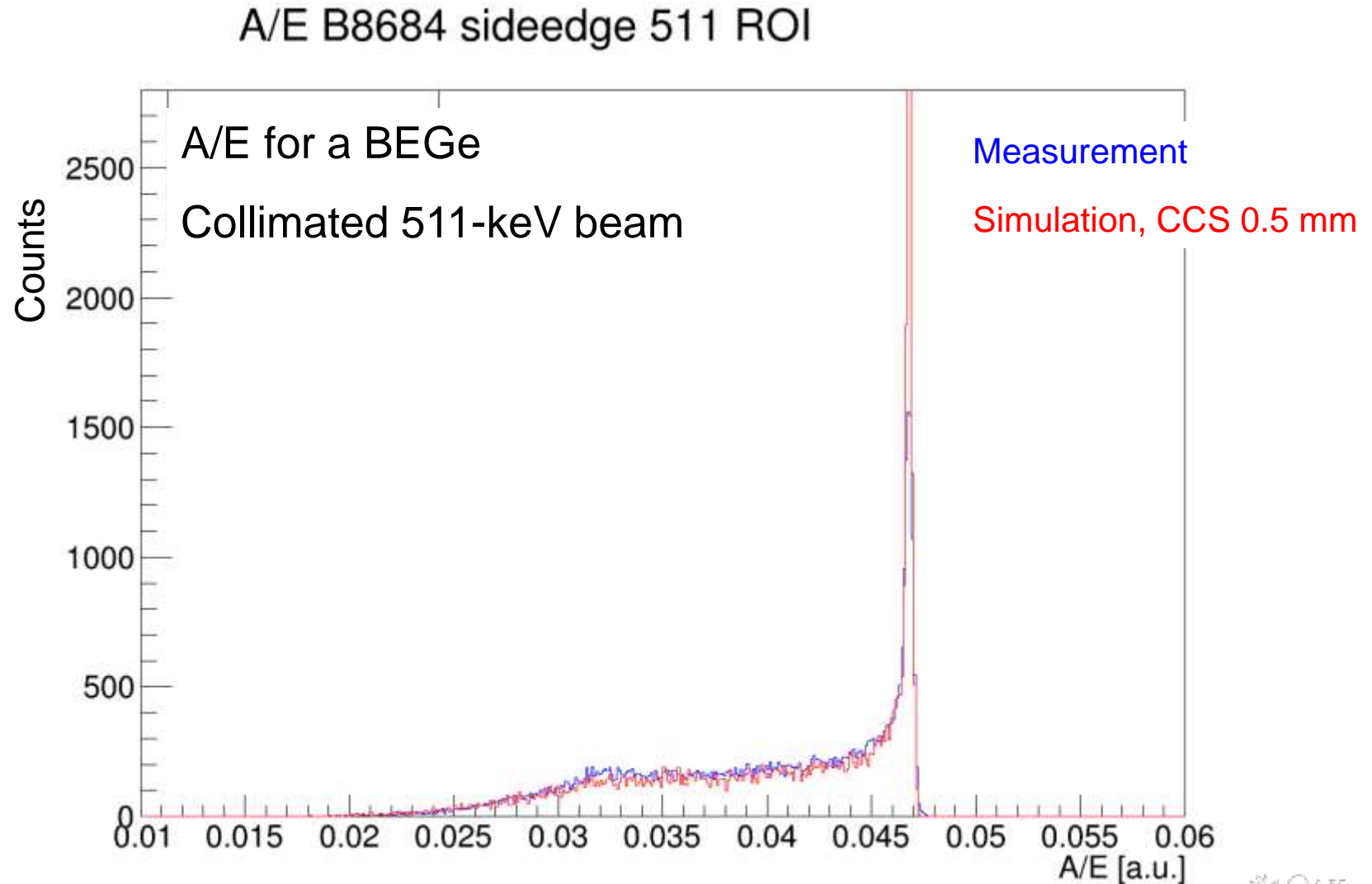


Signals Calculated with Pinch-Off



BEGe Event + Signal Simulations

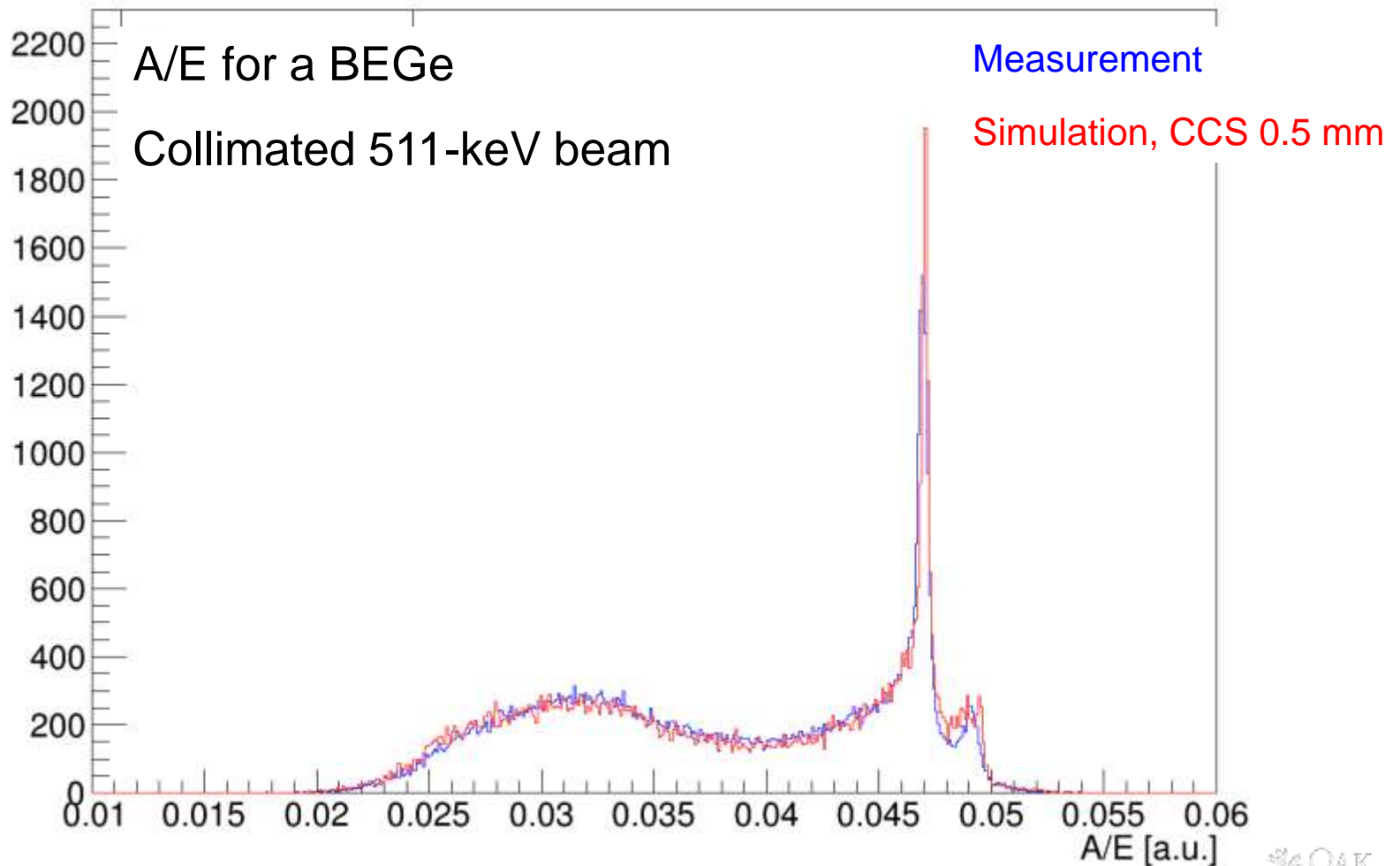
Alex Hegai, Susanne Mertens



BEGe Event + Signal Simulations

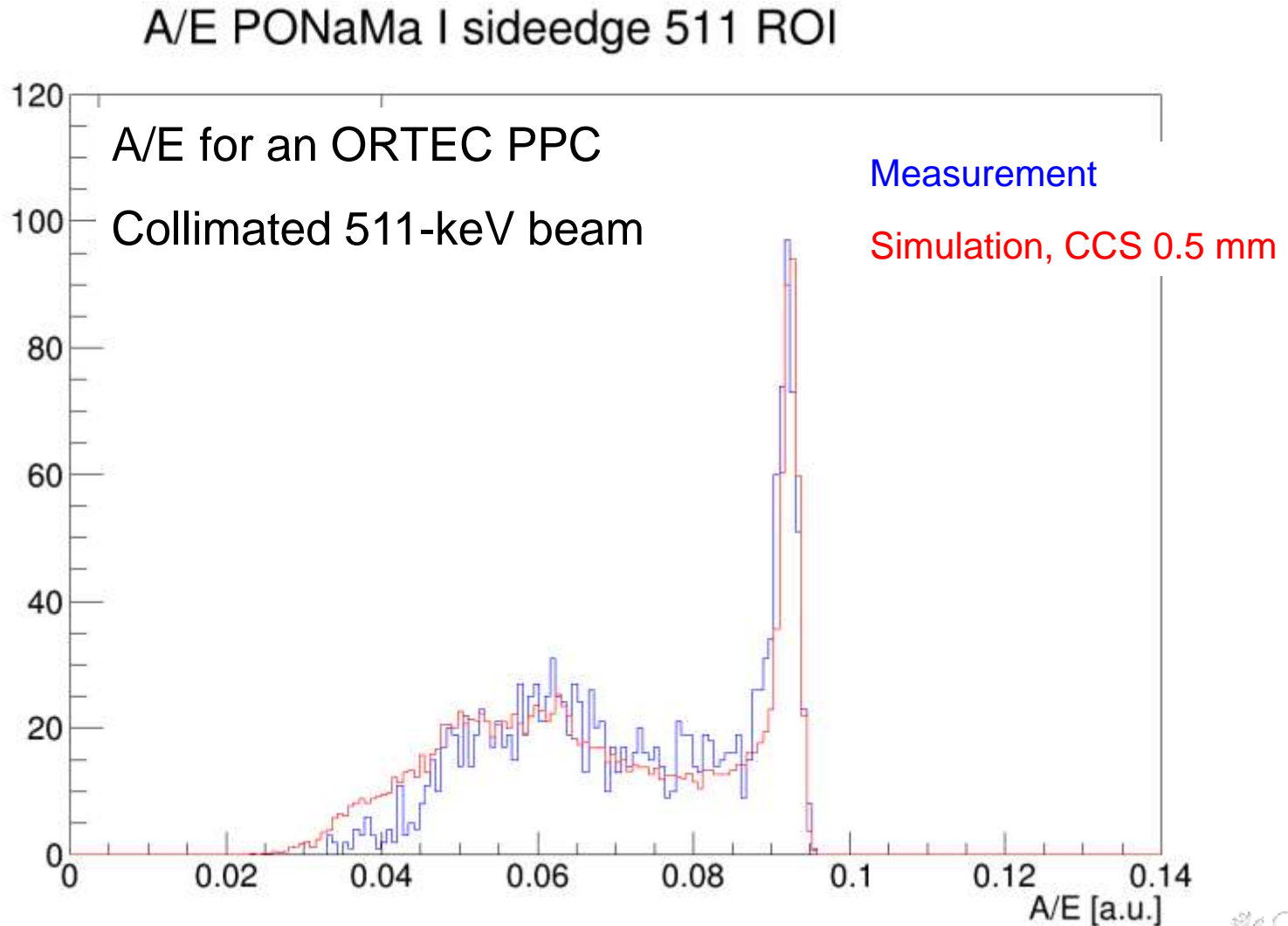
Alex Hegai, Susanne Mertens

A/E B8684 topcenter 511 ROI



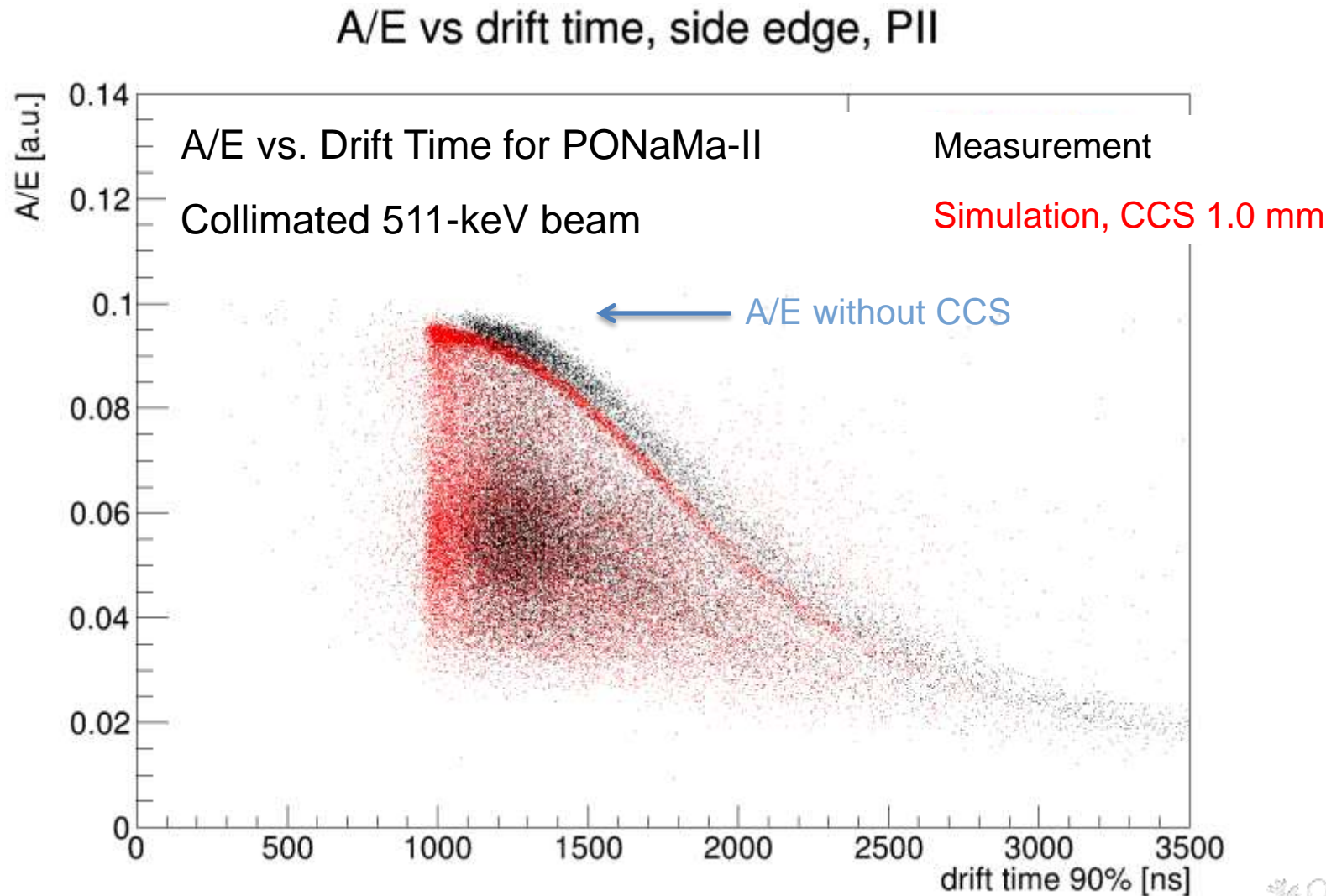
ORTEC Event + Signal Simulations

Alex Hegai, Susanne Mertens



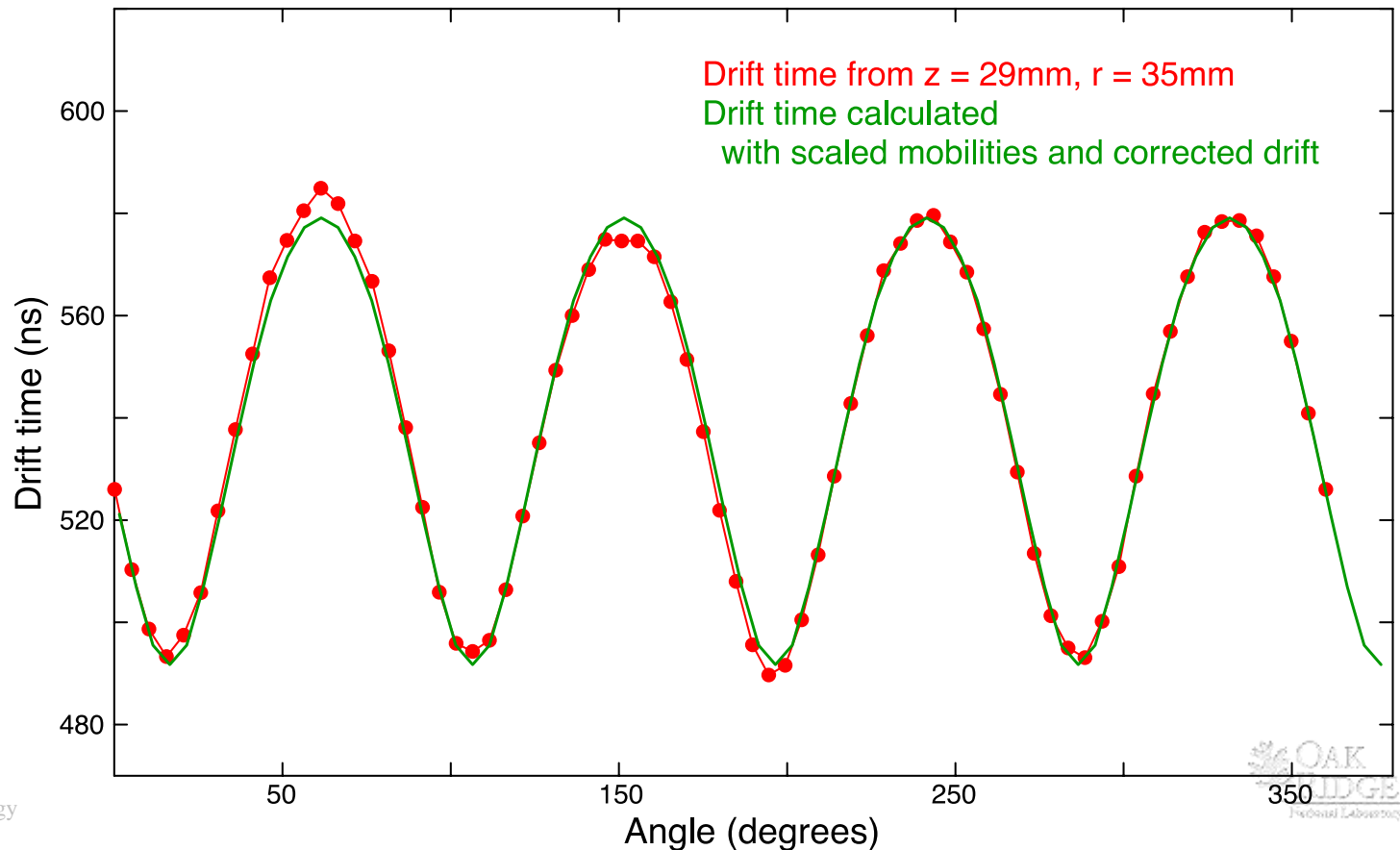
ORTEC Event + Signal Simulations

Alex Hegai, Susanne Mertens



Drift Time: Azimuthal Scan

- Collimated Am source scanned around the circumference of Seg NPC
- Five minutes per point, highly reproducible (~ 1 ns)
 - Determine crystal axis to ~ 0.5 degrees
- Good fit requires adjusting both the electron mobilities (from literature) and directional asymmetry

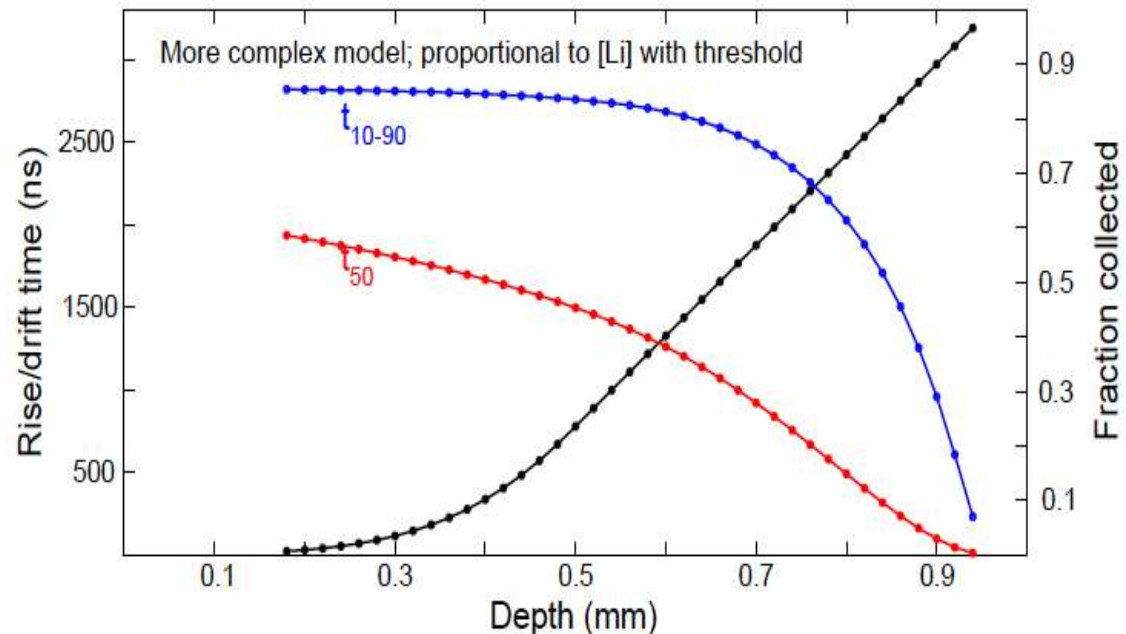
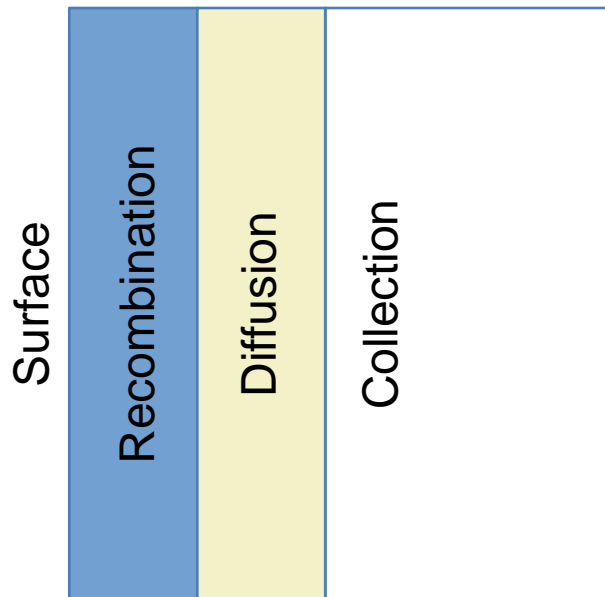


Slow Signals from the Li Transition Layer

Paddy Finnerty, Graham Giovanetti

Not part of standard **siggen**

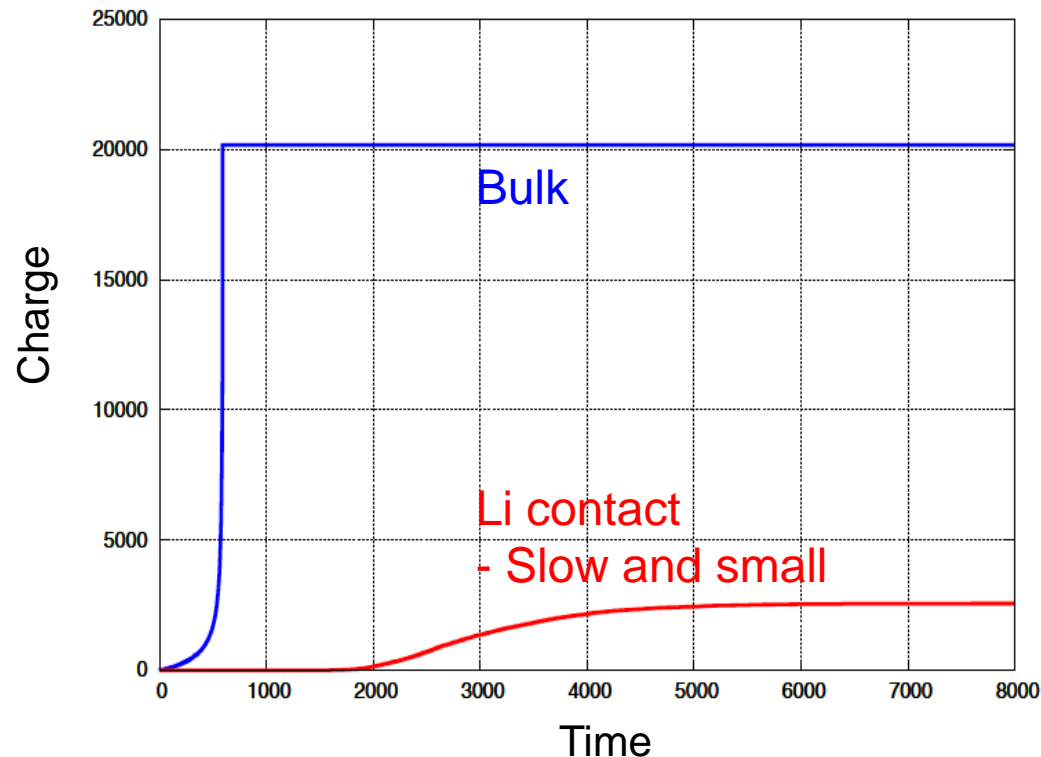
- Developed physical model of the Li “dead layer” and “transition layer”
 - “Recombination zone” close to the surface
 - “Diffusion zone” from there to the bulk



Slow Signals from the Li Transition Layer

Paddy Finnerty, Graham Giovanetti

- Convolute diffusion result with normal **siggen** output to get degraded signal shape



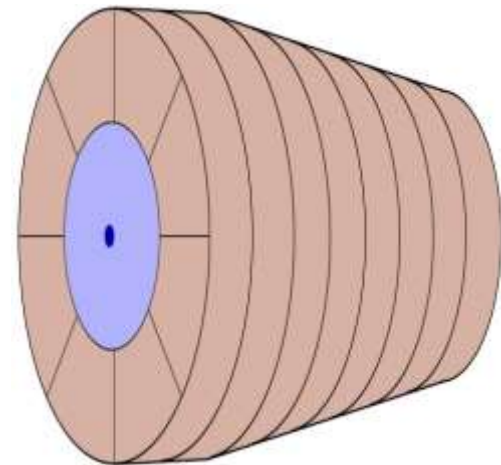
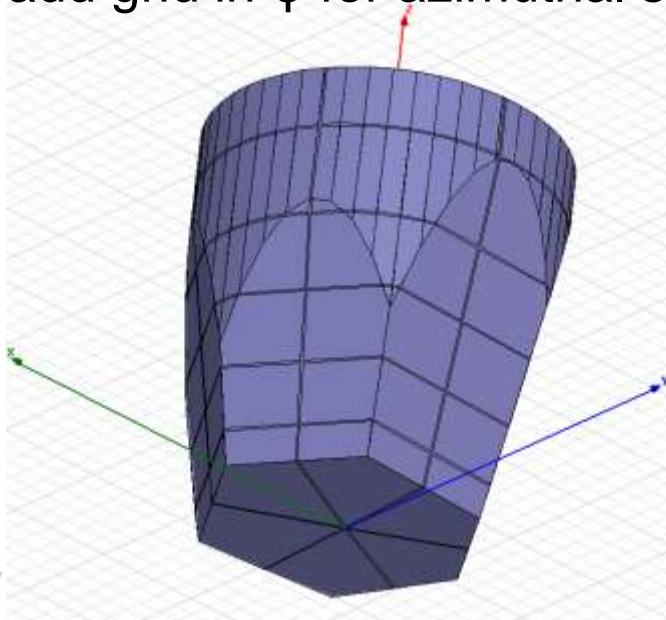
Detectors without Cylindrical Symmetry

3D calculations are much slower in **fieldgen**

- Generally requires a coarser grid
- e.g. GREYINA: $(1\text{mm})^3$ rather than $(0.1\text{mm})^3$ for PPCs

Examples:

- GREYINA detectors (hexagonal taper, azimuthal segmentation)
- Segmented PC detectors (WP of azimuthal segments)
 - In this case, can use the same (r,z) grid as other potentials, and add grid in ϕ for azimuthal segments only



Summary

- Programs for field and signal calculation are open source
 - Incorporated into MAGE
 - Fast and easy to use
 - Include effects such as pinch-off, charge cloud size and diffusion, ...
 - Results generally agree well with measurements

Acknowledgements

Many, but especially

- I-Yang Lee (LBNL)
- Karin Lagergren, Ren Cooper (ORNL)
- Alex Hegai, Susanne Mertens, Paddy Finnerty, Graham Giovanetti